PRIVATE AND CONFIDENTIAL

RESEARCH DEPARTMENT

VISIT TO HOLLAND

MAY 1959

Report No. A-052

(1959/17)

THE BRITISH BROADCASTING CORPORATION
ENGINEERING DIVISION

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G.J. Phillips, M.A., Ph.D., B.Sc., A.M.I.E.E.

(G.J. Phillips)

D.E.L. Shorter, B.Sc.(Eng.), A.M.I.E.E.

(D.E.L. Shorter)

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1. INTRODUCTION

Following technical discussions with Dr. Geluk, Head of the Laboratory of the Nederlandse Radio-Unie (N.R.U.), on the occasion of the I.E.E. Convention on Stereophony in March, a visit was undertaken on 28th and 29th May 1959 to the N.R.U. establishment in Hilversum. The primary object of the visit was to hear a demonstration of the f.m. sub-carrier system which is being used for experimental transmissions at Hilversum and to exchange technical information with the N.R.U. staff concerned with work on stereophony. However, the opportunity was also taken to see some of the design work being carried out in the N.R.U. laboratory and to visit studios and technical areas including the K.R.O., the A.V.R.O. and the new V.A.R.A. sound studios in Hilversum as well as the television studios in Bussum.

In the following sections, matters dealt with during the visit are arranged according to subject matter, irrespective of chronological order.

2. STEREOPHONIC TRANSMISSION SYSTEMS

Equipment had been set up in the N.R.U. laboratories for experimental transmission and reception on v.h.f. by the f.m. sub-carrier system. In the case of the transmitting end, a separate multiplex adapter unit had been constructed which could feed into the modulation input of a standard transmitter; the dimensions of the unit were approximately 12 in. x 8 in. x 5 in. (30 cm x 20 cm x 12 cm). At the time of the visit a transmitter of 1 kW nominal power was installed in the N.R.U. building and was being used to radiate test signals. Although a 3-tier "clover-leaf" aerial was available on the roof of the building, this was temporarily out of action and radiation was, therefore, from a dipole installed at the top of the mast, the height being approximately 80 ft (24 m) above ground level. For the purposes of testing the system, the Hilversum One programme was being radiated directly on the main carrier, and the Hilversum Two programme was used to modulate the sub-carrier.

Only two receiving equipments had been built; each consisted of a multiplex adapter unit designed to operate from the discriminator output of a standard f.m. receiver and to feed two loudspeakers. The adapter was of open construction and slightly larger than the multiplex unit at the transmitter, but could clearly be accommodated, if required, in about the same space.

The circuit details of the multiplex units have been given in the E.B.U. Review[1] but two changes have been made since the publication of this article. First, an improvement has been made to the high-pass filter which is required in the sub-

carrier signal channel of the transmitter multiplex unit. Originally, a simple resistance-capacitance filter was used, but it has since been found desirable to use a 25 kc/s cut-off high-pass filter including inductive elements in order to reduce cross-talk from the sub-carrier signal into the main channel. Secondly, although the deviations of the main carrier remain as originally given, namely ± 55 kc/s and ± 20 kc/s by the main and sub-carrier signals respectively, ± 15 kc/s is now preferred instead of ± 20 kc/s for the deviation of the sub-carrier.

Most of the experiments have been carried out with two different programmes, since the N.R.U. policy appears to be that any multiplex system adopted for stereophonic broadcasting should also be capable of providing, as an alternative, a subsidiary monophonic programme. The possibility of a form of local broadcasting is envisaged which could be offered in addition to the main service on those occasions when a stereophonic programme is not being transmitted. It is thought that if the performance of the system were good enough for a two-programme service, there would be no difficulty in using it for stereophonic broadcasts. In the latter case, the principle used by Crosby would be adopted, i.e. the sum of the left and right channels would be radiated as the main signal while the sub-carrier would be used for the difference signal; consideration would have to be given to any correction of the phase difference between these signals necessary to avoid cross-talk between the stereophonic channels.[2]

Reception of two programmes from an aerial inside the building was heard, but under these conditions cross-talk in both directions between the channels was noticeable. In view of a later demonstration of reception under more typical conditions, this result was not taken as representative.

During the course of the visit to the K.R.O. studios, which are about 3 km from the N.R.U. laboratory, reception of the multiplex transmitter was demonstrated on equipment installed in the building. A dipole aerial had been erected approximately 20 ft (6 m) above ground, and a standard Grundig table model a.m./f.m. receiver was used to feed the N.R.U. adapter, two loudspeakers being provided for listening to the main and sub-carrier programmes. The first impression was that the reception was very good on both channels, but it was soon apparent that impulsive interference was present on the sub-carrier channel. With the preferred standards of modulation, the following table gives the subjective appraisal of the impulsive interference, first with the dipole as initially set up, secondly with the dipole deliberately positioned to give a weak signal, and finally with the dipole set for optimum orientation. It should be noted that this was for fairly continuous traffic within 40 yds (36 m) of the aerial.

Subjective assessment of impulsive interference

Input to receiver (measured on separate meter)	Main channel	Sub-carrier channel
300 μV	"just perceptible" on occasions	"slightly disturbing"
50 μV	"slightly disturbing" to "disturbing"	"very disturbing"
400 μV	"imperceptible"	"slightly disturbing"

In regard to the cross-talk, no disturbance of the main channel by the sub-carrier channel could be heard. On the sub-carrier channel, cross-talk was only just perceptible and was more or less an undistorted version of the main signal. The standards of deviation were then changed at the transmitter, and the performance was heard for 37·5 kc/s peak deviation of the main carrier for both main and sub-carrier signals. For the 50 μV input condition, impulsive interference was more nearly equal on the two programmes than previously, though still perhaps 4 to 6 dB worse on the sub-carrier channel. The demonstration was of interest because, as may be seen from the above table, a degradation of impulsive interference on the sub-carrier channel appears to be of the same order as that expected theoretically for random noise. It would, however, be unwise to attempt to deduce any quantitative result from the brief period of listening. No systematic experiments covering a number of sites have yet been carried out by N.R.U.

The receiver unit was, of course, also capable of taking the sum and difference of the main and sub-carrier channels for applying to the two loudspeakers as required with the Crosby stereophonic system; we were not, however, able to hear any tests of the system either with a stereophonic programme source or with two different programmes applied to the left and right channels rather than the main and sub-carrier channels.

In the course of discussions on stereophonic systems, it emerged that the Philips organization has been proposing a sub-carrier system for stereophonic broadcasting in which full amplitude modulation of the sub-carrier is employed, i.e., a carrier-suppressed type of modulation is not used. The N.R.U. had done some experiments on this system and found the cross-talk between the main and sub-carrier channels was such as to rule out the possibility of its use for a second programme service, though it might be acceptable for stereophonic broadcasts. It also emerged that the figures for theoretical performance which Dr. Geluk had given at the I.E.E. Convention on Stereophony were based on those for both a.m. and f.m. sub-carrier systems given by Dr. Stumpers of the Philips organization. It was pointed out to Dr. Geluk that these figures for the f.m. sub-carrier system differed by 3 dB from those given by our calculations, but it was not possible at the time to discover the reason for this discrepancy.

The N.R.U. did not exhibit any interest in systems of stereophonic broadcasting on a.m. transmitters.

No experimental work has been done by the N.R.U. on the single sideband a.m. sub-carrier systems for f.m. transmitters, such as those proposed by Siemens in Germany and Philco in the U.S.A. Dr. Geluk has only recently given consideration to these systems but has realized that they could offer some advantage in that the complete modulating signal, i.e. the main signal plus sub-carrier signal, could be confined to a frequency range of only 0 to 30 or 40 kc/s. It is attractive, therefore, with this system to consider the possibility of generating the complete modulating signal at the studio source and of feeding it over suitable carrier telephone channels to the transmitter. Subject to satisfactory delay/frequency characteristics, such an arrangement would avoid the difficulty of closely matched pairs of lines for the left and right stereophonic signals which are necessary to ensure, on the one hand, good stereophonic performance and, on the other hand, a satisfactory compatible monophonic signal.

In discussing the potential applications of a multiplex system, Dr. Geluk pointed out that it could be very useful on the f.m. sound channel of the Dutch television service. For example, if a foreign film is being shown, the main channel could carry the original language and the sub-carrier channel the dubbed version. This could effect considerable saving in expense over the present system of providing visual translated captions.

It was also learned that N.R.U. are preparing for tests on the system, proposed by the Bell Telephone Laboratories,[3] for enabling either channel of a stereophonic transmission to be received as a compatible monophonic programme. This system, which has already been the subject of some investigation by Research Department, involves the introduction of audio-frequency time delays of the order of 3 to 30 ms; N.R.U. have modified the head assembly of a magnetic tape recorder for the purpose.

3. PRODUCTION OF STEREOPHONIC PROGRAMME

At the request of Dr. Geluk, a tape recording originally produced for demonstration at the I.E.E. Convention on Stereophony in March 1959 was taken to Hilversum and reproduced in the N.R.U. acoustics laboratory for the benefit of various interested parties. The recordings included a wide variety of programme material as well as some special items illustrating the difficulty of deriving a "compatible" signal. The two loudspeakers provided in the laboratory contained 8 in. (20 cm) Philips twin-cone units type 9710M which, while having a high-frequency response above the average for a cone unit of this type, could not be described as "wide range". In spite of this shortcoming, however, the demonstration was very effective and evoked favourable comment on the B.B.C. stereophonic technique.

A short dissertation was given by Mr. Dorreboom, who is in charge of audio frequency work at N.R.U., on the experimental transistorized stereophonic studio equipment which is now being designed.

The most interesting feature of the design is that the input of each stereophonic microphone channel consists, not of the usual left-hand and right-hand signals, but of the sum and difference of these. In the case of a stereophonic system operating only on amplitude differences between the left-hand and right-hand signals, it is well known that the sum signal can be directly generated by a single forward-pointing microphone and the difference signal by a second microphone having a figure-of-eight directional pattern and mounted at right angles to the first; for this reason the sum and difference signals, which in a multiplex transmission system would be applied respectively to the main and sub-carrier channels, are often designated by the letters M and S - denoting "middle" and "side".[2] In the new studio equipment, it is proposed, in general, to produce the M and S signals directly by the use of microphones directed forwards and sideways in the manner just described; since, however, the matching of the amplitude and phase characteristics of the two types of microphone may be difficult, the normal arrangement of left-hand and right-hand microphones will be used for specially high-quality work, the sum and difference being then extracted electrically.

In deriving the M and S signals at the input rather than at the output of the studio control equipment, the design was influenced by the idea that the layout of

the microphones and the mixing of their outputs would be based on the requirements of the monophonic programme. Thus, the M signals from the various microphone channels would be taken to an independent control desk, the corresponding S signals being separately regulated to give the desired stereophonic effect. The engineer operating the stereophonic circuit would then have no independent control over the mixing of microphones. His function would be confined to adjusting for each channel (a) the ratio M/S, which determines the scale of width, i.e., the relationship between the angular displacement of a source of sound and that of its reproduced image, and (b) a "steering" control capable of applying a left or right bias to the reproduction. N.R.U. are confident that good stereophonic and good monophonic programmes can be simultaneously obtained by this means. It was subsequently learned, however, that apart from early work with a dummy head they have not carried out any studio experiments and have, therefore, no practical experience of modern stereophonic microphone techniques.

4. STUDIO AND CONTROL ROOM EQUIPMENT

4.1. General

A few observations made in the course of visiting control rooms and cubicles may be worth recording.

Modulation is indicated by a long scale peak programme meter similar to that used in Germany, the charge time constant being of the same order as that of the B.B.C. instrument, but the return time rather less. The peak programme meter is supplemented by a c.r.o. display of the transmitter modulation in the form of a trapezium; this double check is necessitated by the fact that the studios, lines and transmitters are not in the same organization. The indications of the P.P.M. are automatically registered on a recording chart in the studio cubicle for subsequent routine inspection. In some cases, the meter current is chopped to produce a.c., thus enabling a standard Brüel and Kjaer level recorder to be used; alternatively, a d.c. recorder working on the "Hellschreiber" principle is employed.

Variable correction units are provided for disk replay. The degree of correction to be applied to recordings is not, however, left to the discretion of the operator concerned; instead, the dial settings are marked on the disk in advance by the staff responsible for quality checking.

All faders are of the familiar German slider type. Originally these were constructed with the "off" position towards the front of the control desk and it was easy for a channel to become partly faded up through an accidental movement of the operator's hand; in later installations, the "off" position is at the rear.

In the portable equipment used for outside broadcasts, slider type faders are again used, but these, while similar in appearance to those in the cubicles, employ a carbon track resistance element, occupying less depth. These fader controls are mounted on a shallow horizontal shelf which can be pushed in like a drawer when not in use.

Each set of studio equipment is fitted with an indicator to show the number of running hours; maintenance is undertaken on all studio apparatus, including

microphones, every 1,500 hours. The master switch in each cubicle is controlled by a lock to prevent the equipment from being switched on by unauthorized persons, from which it may be inferred that unnecessary running time is probably reduced to a minimum.

4.2. Microphones

The majority of microphones in both sound and television studios are of an electrostatic cardioid type designed and manufactured by N.R.U. There are two versions of the design, both employing the same capsule. This is in one case coaxial with and in the other at right angles to the cylindrical pre-amplifier housing. The capsule appears to be robust in construction but is somewhat large, and it is not surprising that the directional characteristics at high frequencies, judged from N.D.R. measurements, are not impressive by modern standards. It was stated that a new diaphragm can be fitted to one of these capsules in ten minutes; further enquiry, however, elicited the fact that there is no means of testing the diaphragm tension, this being left to the personal judgement and skill of the one man assigned to the work.

Apart from the above, the only unfamiliar type of microphone seen was an omnidirectional moving-coil model, M100, made by the German firm Beyer, which was in use in an echo room and also in a studio as a standby.

For measurement of microphone performance, a dead room having 20 in. (0·5 m) long absorbent wedges is available but, as there is no travelling-wave duct, it is not possible to measure accurately the plane-wave response, and in particular the directional characteristic, at low frequencies.

4.3. Loudspeakers

The opportunity was taken of examining the construction of the latest N.R.U. monitoring loudspeaker. This had been originally designed with a single 8 in. (20 cm) twin-cone Philips unit, type 9710M, already referred to in Section 3 but, at the request of the programme staff, a subsidiary unit, type 9750, covering a restricted frequency band, had later been added to give them the timbre to which they had been accustomed. A separate compartment within the main enclosure was provided for the subsidiary unit, the output of which is about 6 dB below that of the main unit. The main enclosure has an internal volume of 7·3 ft^3 (0·2 $metre^3$) and external dimensions approximately 2 ft wide × 4 ft high × 1 ft deep (60 cm × 120 cm × 30 cm); the amplifier is housed elsewhere.

The standard of cabinet work displayed in the enclosure is high out of all proportion to the type of loudspeaker units employed. The quality of reproduction, as far as could be judged on the programme material available, was not impressive.

4.4. Reverberation Rooms

At the A.V.R.O. studios one of the two reverberation rooms used for effects is provided with an acoustic transmission tube to delay the microphone output. The tube, of hard plastic material and of approximately 1 in. (2·5 cm) bore, runs along three walls of the room and includes three right angle bends, each on a radius of some

4 in. (10 cm). The microphone, a moving-coil type M100 already mentioned, is let into an opening in the side of the tube, which is carried on for a further 2 ft (60 cm), with a filling of sound absorbent material as a termination. The overall length of tube is about 46 ft (14 m) giving a delay of some 40 ms.

In the reverberation room visited, an attempt had been made to improve the sound diffusion by laying alternate bricks endways so as to project from the wall; the projecting end of each brick was broken off roughly, to a "random" length before laying. The effect of this irregularity in wall surface would, of course, be confined to high frequencies. A Helmholtz resonator was being used to suppress one of the unwanted low-frequency modes in the room.

Both the reverberation rooms at the A.V.R.O. studios suffer from damp which arises from recent building operations and is expected to persist for some years. To avoid damage to the loudspeaker and microphone as well as a change in sound absorption which would result from excessive humidity, refrigeration type drying equipment is installed in each room; this apparatus, which makes a certain amount of noise in operation, is automatically switched off whenever the room is brought into use.

5. ACOUSTICS RESEARCH

An application of stereophony to the subjective assessment of studio acoustics was demonstrated in the laboratory. An impulsive sound, produced by an electric spark, was picked up by a pair of coincident cardioid microphones and, after recording, was reproduced stereophonically at a quarter of the original speed. The results were demonstrated for a number of different studios covering a wide range of dimensions. The fourfold expansion of the time scale together with the stereophonic presentation made the difference between the acoustics of the various studios and, in particular, the degree of sound diffusion obtained, very evident.

Equipment for displaying on a c.r.o. the complex ratio between a pair of sinusoidal voltages at the input and output of a transmission chain was also shown. The circuit is on conventional lines, producing rectified voltages proportional to the real and imaginary components of the output/input ratio. The apparatus can be used to indicate simultaneously the phase and amplitude changes which take place during the build-up and decay of sound in a room – a rough demonstration of the effect was given in the laboratory – and this information is of value in research on studio acoustics.

6. TELEVISION

A short visit was made to the television studios at Bussum, a few miles north of Hilversum. The equipment here is not the responsibility of the N.R.U. but of a sister organization, N.T.S., the technical head being Mr. C.J. Mol. At the present stage of development the studios are housed in a number of different buildings near the centre of Bussum, one of which had originally been a church.

Much of the television studio and control equipment, including most of the cameras, is from the German firm Fernseh G.m.b.H. One super-iconoscope has a five-

lens turret including a wide-angle lens with a large objective (about 10 cm diameter). For reasons of economy some modified commercial table-model receivers are being used as monitors, while the electronic "wiping" equipment, which allows push-button selection of several wiping patterns, has been made by the N.T.S.

Commercial telerecording equipment using the suppressed-frame principle is available in one of the studio buildings. "Reversal" film exposed to a positive c.r.t. picture is always used for telerecordings, and is processed to yield a positive print directly; similar film is also favoured for ordinary newsreels when the printing of a positive from a negative film is not justified.

7. CONCLUSIONS

Work in N.R.U. on stereophony has so far been concentrated on possible systems of multiplex transmission applicable to a v.h.f. sound service. Small-scale experiments with an f.m. sub-carrier system have commenced, but have not yet reached the stage of making systematic observations at a number of receiving sites. In any case, performance tests have so far been confined to the main and sub-carrier channels individually, interest being directed initially to the possible alternative use of the sub-carrier for a second sound programme.

Very little practical work has been done in N.R.U. on the problems of studio technique in stereophony, but a certain amount of control equipment is being designed.

8. REFERENCES

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